HER MAJESTY'S GEOLOGICAL SURVEY

OF THE

UNITED KINGDOM,

AND ITS CONNECTION WITH

THE MUSEUM OF IRISH INDUSTRY

IN DUBLIN,

AND THAT OF

PRACTICAL GEOLOGY IN LONDON,

An Address

DELIVERED (AT THE REQUEST OF SIR ROBERT KANE) BEFORE HIS EXCELLENCY THE MARQUIS OF ABERCORN, LORD LIEUTENANT OF IRELAND, ON THE OCCASION OF HIS DISTRIBUTING THE PRIZES TO THE SUCCESSFUL STUDENTS AT THE MUSEUM OF IRISH INDUSTRY, ON DEC. 21st, 1866.

BY J. BEETE JUKES, M.A., F.R.S.
(LOCAL DIRECTOR OF THE IRISH BRANCH OF THE GEOLOGICAL SURVEY, AND LECTURER ON GEOLOGY TO THE MUSEUM)

DUBLIN:
HODGES, SMITH AND CO., GRAFTON STREET,
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NOTE.

The publication of this little brochure has been delayed in consequence of numerous engagements having prevented my attending to it. I am, however, in consequence, enabled to correct an error. Sir Robert Kane has just informed me that his appointment was from the first that of "Director," and not that of "Chemist," to the Museum. I had always understood previously that his original appointment had been like that of Dr. Lyon Playfair to the Museum in London.

January 14*th*, 1867.

AN ADDRESS,

ETC.

MAY IT PLEASE YOUR EXCELLENCY,

Ladies and Gentlemen—I have been requested by Sir R. Kane, the Director of this Institution, to lay before you some account of the Geological Survey—its history, its mode of operation, and its connection with the Museum of Irish Industry. I gladly avail myself of this opportunity to bring under your notice a great national work which has now been in operation for more than twenty years, labouring under many difficulties and much discouragement, but still continuing to labour on, in the hope that its utility would ultimately be recognised, and its value proved, by the best of all tests, that of results obtained.

Let me at once guard myself by saying that I do not mean solely, or chiefly, money value, or what is called practical utility. The cost of the Survey will ultimately be repaid to the nation either in actual gain, or in the saving of fruitless expenditure, and, perhaps, repaid ten times over.* But I should be false to my own convictions if I did not rate intellectual gain at

* See Appendix, Note A.

a far higher value than any material profit, and did not put the scientific results of the Survey of the Heavens and the Earth, carried on by the Royal Observatories, and Her Majesty's Geological Survey, far before their practical application to navigation and mining.*

Origin of the Geological Survey and Museums and Lecture System.

About the year 1832, Sir Henry (then Mr.) Dela Beche having for some time previously worked at the Geology of the West of England, proposed to the Government to publish geologically coloured copies of the Ordnance Maps of Devon and Cornwall.

In that year accordingly a sum of £300 was set apart for the purpose in the Ordnance estimates, "Mr. Dela Beche contributing the remainder and "greater portion of the expense." In subsequent years larger public funds were supplied and a small geological branch of the Ordnance Survey formed under Mr. Dela Beche, the late General Colby being then at the head of the Ordnance Survey.

In the year 1835 Mr. Dela Beche, being, as he says in his Inaugural Address, in Jermyn-street, in the year 1851, "forcibly impressed that this Survey pre- "sented an opportunity of illustrating the useful "applications of Geology, ventured to suggest to Mr. "Spring Rice," (the late Lord Monteagle) "then

* See Appendix, Note B.

"Chancellor of the Exchequer, that a collection "should be formed and placed under the charge of "the Office of Works, containing specimens of the "various mineral substances used for roads, in con- "structing public works or buildings, employed for "useful purposes, or from which useful metals were "extracted, and that it should be arranged with "every reference to instruction."

In order to carry out this idea of instruction, Sir Henry designed that the scientific officers attached to the Survey should give courses of lectures in their several subjects, and he tells us in his Inaugural Discourse that so early as the year 1839 the sanction of the Treasury was given to this design. It was not, however, till the year 1851 that a suitable building having at length been completed in Jermyn-street, Sir Henry was enabled to inaugurate what he describes as a "system of instruction new to this country, one "which does not interfere with existing institutions; "on the contrary, it may be considered as assisting "several, inasmuch as while it provides for a want "which they do not supply, it refers to knowledge "which they teach." *(Ibid*, p. 1).

In Ireland, in the meantime, a simultaneous movement had occurred, owing largely to the enlightened advice of Sir T. Larcom (the present Under-Secretary for Ireland), and a Geological branch of the Ordnance Survey was formed about the year 1832, and placed under the charge of the late General (then Captain) Portlock.

Large Geological collections were made, and also collections of Zoological and Botanical specimens, and were formed into a museum in the Ordnance Survey Office in Belfast about the year 1837, and the well-known "Report on the Geology of Londonderry and "parts of Tyrone and Fermanagh," by Captain Portlock, was published in 1843.

About the year 1844, however, it was decided by the Government of the day (that of the late Sir Robert Peel) to detach the Geological Surveys from the Ordnance Department and consolidate them into one under the Office of Woods and Forests, Sir Henry T. Dela Beche being appointed Director-General of the Geological Survey of the United Kingdom.

In 1845 an Act of Parliament was passed (technically quoted as the 8th and 9th Victoria, cap. 63) giving the necessary powers to all duly appointed officers of the Survey and their assistants to examine every portion of the country without fear of being prosecuted as trespassers on private property.

In a Treasury Minute of December 27th, 1844, it is said to be necessary for the purposes thus indicated "to provide an adequate building in London "and Dublin respectively, calculated at once to afford "facility for inspection to the public and ready means "of information to those engaged in scientific pur-"suits." (See *Report of the Committee of the House of Commons on the Scientific Institutions of Dublin*, 1864, p. 121).

These buildings, from the very first, were designed

with lecture theatres for the delivery of lectures, galleries for the display of the collections, and offices and work-rooms for the officers of the Survey, and both had laboratories attached to them in which the chemical researches useful or necessary to the Survey could be carried on, as well as such other investigations made as might, from time to time, be required by the public service.

The Dublin Museum received at once the Geological and part of the Zoological and Botanical collections formed under Captain Portlock by the Geological branch of the Ordnance Survey, and a set of duplicates from the English collections, and has of course been ever since the chief repository of the collections formed in Ireland by the Irish branch of the Geological Survey.

Both museums were at first called Museums of Economic Geology, a title which was afterwards modified in London into that of Practical Geology, while in Dublin it was exchanged for that of Irish Industry. This change was made under the direction of your Excellency's distinguished predecessor, the late Earl of Carlisle, when, as Lord Morpeth, he was First Commissioner of Woods and Forests in the year 1847.

Sir Robert Kane, who in 1845 was appointed Chemist to the Museum, was then made Director of it, and its scope was enlarged beyond its original design to that indicated by the title it has since borne.

Your Excellency will now perceive how closely

these scientific institutions are united, and how, while the ideas on which they were based were simultaneously stirring in many men's minds, we may look back to Sir Henry Dela Beche, as the man to whose energy and influence they owe their actual existence.*

His design included a system of observation and investigation in the field, museums in which the collections could be examined and classified for the guidance of the field-workmen, and displayed for the information of the public, and a particular kind of instruction to be given to that public, which, among other advantages, would ultimately enable them to appreciate and utilise the results of the Survey.

In England, Professor Ramsay, who joined the Survey while under the Ordnance in 1841, was appointed Local Director for Great Britain in 1845, an office he still retains.

In Ireland, the first Local Director was Captain (now Colonel Sir Henry) James ;† he was shortly succeeded by Mr. (now Dr.) Oldham, who left us in 1850 for the more lucrative appointment of Superintendent of the Geological Survey of India, when I was appointed to succeed him, having originally joined the Survey in 1846 on my return from the voyage of H. M. S. Fly.

On April 11th, 1855, we lost our founder, Sir H. Dela Beche, whose health had been gradually failing for some years, and he was succeeded in the Director-

* See Appendix, Note C.

† Now Director of the Ordnance Survey.

Generalship by Sir R. I. Murchison, who, although not previously belonging to our staff, was appointed, not only with the concurrence, but I may almost say, on the petition of the whole of it.

Meanwhile the office of Woods and Forests was modified, and on the formation of the Department of Science and Art, in the year 1854, our establishments were consigned to it, at first under the Board of Trade, and afterwards under the Committee of Privy Council for Education.

For the first ten years the Irish branch of the Survey was worked by three field surveyors and the Local Director, and the means at their disposal were most inadequate, a surplus of £113 per annum being all that remained after payment of the salaries, to cover travelling expenses, carriage of boxes and parcels, labourers, postage, and all incidental expenses.

That the salaries were not very luxurious, will be seen, when I state that they varied from 7s. to 10s. a day, the highest pay being £200 per annum, and that of the Local Director £300.*

In the year 1854, however, an increase both in the number of our staff and in our rate of pay was granted to us.

We now have five senior and two assistant geologists† (when our number is complete), two fossil col-

* See Appendix, Note D.

† Two of these however perform office duties, one that of Palæontologist, and another that of Secretary and Clerk of Stationery, &c., so that our field workmen are only five, and for the last few years have never actually been more than four working in the field.

lectors, and one office messenger, making with the Local Director eleven persons, whose united salaries amount to £2,750 per annum, forming, with the allowance of nearly £800 for travelling and incidental expenses, an item of £3,527* a year in the Estimates.

Mode of Operation of the Survey.

It was in the year 1852 that Sir Henry Dela Beche at length procured the Government sanction for the construction of a one-inch Ordnance Map of Ireland. This had been often previously urged in vain by the Ordnance Department, the necessary authorization being then given at the urgent instance of Sir Henry primarily for the publication of the results of the Geological Survey.†

In describing our mode of operations, then, I shall confine myself to Ireland, where we have now the great advantage of the Ordnance Maps, both on the six-inch, and the one-inch scale, over the whole country, and where consequently it has been possible to devise a plan of operations that could not be so perfectly carried out without both those maps.

The Local Director assigns to each field geologist a district comprised in one or more sheets of the one-inch map, each of which includes an area twelve miles

* See Appendix, Note D.

† I recollect Sir Henry consulting me in the year 1852, when on his way to the British Association meeting in Belfast, as to the best size of sheet for the one-inch map, and his adoption of my suggestion of 12 inches by 18 inches. Anyone who has had much handling of maps in the field, either for reference or work, will agree with me that larger sheets are most unhandy and troublesome.

from N. to S., and eighteen broad from E. to W., or 216 square miles. Each geologist receives two mounted copies of those one-inch maps, and also two copies of each of the six-inch maps included in his district. These are cut into quarters and numbered according to a regular system, and each quarter sheet is entered in a Map Register,* both in the office, and in that which each officer is supplied with. These Registers have a column for the name of the officer to whom each quarter sheet is issued, and the date of issue, and others for the date of its return completed. The geologist to whom each of these quarter sheets is issued is primarily responsible for its return in a finished state, and if it has been transferred to another officer, that transfer must appear in each officer's Map Register.

Furnished with these maps, and with note-books and the necessary instruments, the geologist enters on his district and fixes himself in the most convenient spot from which to examine it.

He then carefully explores the whole of the area, noting down on the six-inch map, by means of marks, writing and colours, the different rocks, or mineral matters, that he can find exposed in all cliffs, crags, river-courses, or other natural exposures, and also in all quarries, mines, road and railway cuttings, in the ditches surrounding the fields, in the excavations for the foundation of houses, and all artificial exposures, so that no square yard of ground is left wholly

* See Appendix, Note E.

unexamined. He also seeks information from all persons likely to afford it as to matters which may have been exposed formerly, but which are now concealed, and, in short, endeavours to apply as exhaustive a system of inquiry as possible into everything that lies below the surface of the ground. The scale of the six-inch maps allows of the precise locality of every rock or stone being indicated upon them.

This information being in the first instance inserted on the "field," or "working" copy of the maps, is afterwards transferred to a clean or duplicate copy—both copies being ultimately received and stored in the Geological Survey Office where they are kept as Public Records,* containing all the geological data that could be collected at the time the district was examined with the signature of the officer who examined it, at the back of the quarter sheet.

Such observations as could not be recorded on the map are of course consigned to the note-book to be published afterwards in the Explanations.

While thus working with the six-inch maps the geologist transfers from time to time an abstract or condensation of his work to the field-copy of his one-inch map, and ultimately prepares a finished coloured copy of that, showing the results of his examination† with an outline copy for the use of the engraver.

During the progress of the work it is inspected from time to time by the Local Director whose duty it is, in conjunction with the Director-General, to verify

* See Appendix, Note F. † See Appendix, Note G.

the accuracy of each man's style of work and also to harmonise the views and conclusions which he arrives at, with those of his neighbour on each side of him, and with the general results of the Survey.

When an outline copy of the one-inch sheet is finally "*settled*" it is sent into the Ordnance Office to be engraved, and the engraved copies are sent to London to be coloured by Mr. Bone and his assistants, in order that precisely the same tints shall be used to denote the same rocks or formations throughout the United Kingdom.

In the meantime, specimens of the rocks and fossils are collected, either at the time of the first examination being made or subsequently, by our fossil collectors, at the localities indicated by the surveyors. These specimens are each labelled with a number,* preceded by a distinguishing letter, and each specimen, on arrival at the Geological Survey Office, is entered in a Register† with parallel columns, containing its locality, with a reference to the six-inch and one-inch maps; its name, when that is determined; its formation; and its destination, temporary or final as the case may be. These specimens, especially those of fossils, are at first arranged in working drawers in the office till they can be properly examined and determined, and are then either placed in the Museum here, or packed

* We have books of these numbers printed from 0 to 5,000, with a space before each for the insertion of a MS. letter. Each figure can then be cut out as it is wanted, and gummed on the specimen, each collector keeping a catalogue of the specimens he collects.

† See Appendix, Note E.

up for transmission to our Museums in London or Edinburgh, or to other places as the Director-General may determine.*

In the meantime, each field surveyor, before he is considered to have finished his district, has to prepare a MS. "Explanation" of it.

These Explanations are divided into two parts—"General Descriptions" and "Detailed Descriptions." The first is for the general reader, and contains an account—

1st. Of the form of the ground and physical geography of the district. 2nd. A brief account of the rock formations which enter into its structure. 3rd. A sketch of the relations between the external form and the internal structure, and a general account of the latter; and 4th. Palæontological notes on the fossils found in the district, with figures of any new ones.

The "Detailed Descriptions" are intended for persons who wish to examine any part of the district, and either to learn what we have observed in it, or to verify or correct our observations. The district is generally subdivided into smaller areas, and the observations made at each locality are given in detail, sometimes accompanied by wood-cut figures of sketches or small sections. The *mines and minerals* that have been met with, and the observations made on *drift gravels*, *peat bogs*, or *other superficial accumulations*, are also given here.

* See Appendix, Note H.

There is, however, still another matter to be attended to before any district can be considered completed, and that is the construction of a section across it, so as to show the true outline of the ground and the true "lie and position" of the rocks beneath the surface. These sections are drawn on the six-inch scale, both vertical and horizontal.*

In Wales and England this had to be done by the chain and theodolite being carried in straight lines, often for many miles, across the ruggedest and least accessible heights and the steepest and deepest valleys, in which the rocks are most likely to be well exposed.

In Ireland, however, the heights marked on the six-inch maps have made this toil unnecessary, and we have merely to protract the section from these and the geological data which are marked on the "worked maps."

These sections are engraved in London by Mr. Lowry, and coloured by the same persons who colour the maps.

Finally, it is the duty of the Local Directors, or the Director-General, to prepare condensed memoirs upon certain larger areas than those described in the Explanations; areas which have geological rather than geographical boundaries.

Amount of Work done by the Survey.

Up to the year 1854, we had only the small county index maps of Ireland on which to publish our results.

* See Appendix, Note I.

The labours of the Survey then were chiefly devoted to accumulating geological observations on the six-inch maps. When the one-inch maps were first published, all the officers by whom that work had been done (except Mr. Dunoyer) had left us for similar, but better paid, employment in India and the Colonies.*

For some years after 1854, I had, chiefly with young untrained geologists, not only to keep up the number of square miles of newly surveyed area which the authorities take as the test of our progress for the year, but to reduce for publication on to the one inch sheets, all the previously surveyed area. So great was the load of back work, that to this day we have not been able to publish any Explanations of the sheets of the maps which were examined during the early part of the Survey; nor have I been able yet even to visit a good portion of that ground.

The present state of our work in Ireland is as follows:—

The six-inch data maps are completed for the whole of Ireland, south of a line drawn from Clogher Head near Drogheda, by Kells and Granard to Boyle, and thence by Castlebar and Lough Mask, to the shores of Galway Bay, or nearly two-thirds of the whole island.

Of the 205 sheets of the one-inch maps, we have published geologically coloured copies of 102 sheets, and seven more are now being engraved.

* See Appendix, J.

We have published 52 of our Explanations, containing a full description (in 1751 pages, with 378 wood-cut illustrations) of the districts included in all but 14 of those sheets.

We have also published 27 sheets containing Longitudinal and Vertical Sections, including one by Mr. Warrington Smyth containing plans and sections of the Ovoca Mines.

There is at the present moment, under the consideration of the Government, a plan for increasing our staff, so as to hasten the completion of the Survey as rapidly as possible, an object for which I hope I may ask the good wishes of your Excellency, as well as of all those who have listened to me.*

* See Appendix, Note K.

APPENDIX.

A.

Very few people are aware of the enormous amount of the loss which has been incurred, and is even yet of annual occurrence, in fruitless mining enterprises. The loss from bad mining is, I believe, something frightful; but I now more especially allude to that utterly useless expenditure which takes place in the vain search after Mineral Veins or Coal in places where their occurrence is quite hopeless.

Even in such rich mineral districts as Cornwall and Devon, it is said that many of the most experienced mining men there have strong doubts as to whether a profit has been realised on the whole amount of expenditure. Mr. Hunt, in the Mineral Statistics for the year 1862, states the whole value of the tin, copper and lead raised in that district during that year to be nearly three millions sterling. The necessary expenditure in raising that amount is, doubtless, very large, and when to that is added the money spent in the vain search after fresh veins, and the continuance of work on old veins after their riches have been exhausted, it is quite possible that the profits on the whole transactions, even of that year, may have been much smaller than would at first be supposed.

Miners and geologists are equally destitute of that knowledge of the mode of deposition of minerals in veins which would enable them to avoid so great a loss; but it is obvious that this knowledge can only be ultimately attained by the application of the most accurate scientific investigation into the nature and origin of mineral veins, and that the necessary preliminary to that must be the exact delineation of them and their attendant phenomena on maps of a sufficiently large scale to exhibit them clearly and without distortion.

When to the loss incurred in rich mineral districts is added that

which is of yearly occurrence in the search for mineral veins, in remote parts of the United Kingdom, where no one ever hears of it except a few of the peasantry or a stray geologist, the annual cost of the Geological Survey is seen to be a trifle in comparison.

But the money wasted in the search for Coal is almost equally great. The foolish expenditure, of which, during the thirty years of my geological life, I have been myself personally cognizant, cannot have been less than £150,000. The expenditure of which I never happened to hear, must, I should suppose, have been at least as great. The total would make a sum which, capitalised, would pay the present annual cost of the Geological Survey *in perpetuity*.

As a specimen of bad mining, I may mention that, about three years ago, I was consulted by some connexions of my own respecting a coal-pit in the South Welsh coal-field, which had cost something like £30,000. It had been sunk chiefly on the advice of a practical man, who managed an adjacent colliery, but who did not notice that the axis of the synclinal curve in which the beds lay, was itself inclined, and that accordingly the coal of which they were in search had cropped out a mile before reaching the place where the pit was being sunk. This is but one, and by no means the worst, of numerous instances that might be given, and they take place by the score, without ever being known except by accident.

The Geological Survey has already checked much of this fruitless expenditure, and I believe that I have been myself the means of putting a stop to as much of it as would repay the nation the amount of my own salary for the five-and-twenty years I have been in Her Majesty's service. The increase and the spread of geological knowledge generally, however, to which the Survey has contributed, has doubtless produced a still wider effect than is known to any of us.

None know more than the really eminent vein-miners how much their profession is infested by quacks, who often conceal their ignorance under a profuse use of technical mining phraseology. Some of these are doubtless knaves as well as quacks; but the most dangerous class are the honest quacks, men who, having a smattering of mining knowledge, fancy they know everything, and would spend their own money, if they had it, in the enterprises they recommend to their employers. The obvious conviction of the truth

of their fancies and crotchets by which these men are animated produces a necessary effect on the minds of those who suffer themselves to be influenced by them. Moreover, it sometimes happens that their positive and confident assertions cannot be met by any direct proof to the contrary, although the more a man trained to sound logical reasoning actually knew about the matter, the more hesitation he would feel in coming to the conclusions to which they leap at a bound.

B.

Men of science have of late years pandered too much to the utilitarian quackery of the age, and it is time that some one should stand up to protest against it. Government and the House of Commons should be told that science must be supported and encouraged for her own purely abstract purposes, independently of all utilitarian applications. The necessary preliminary, indeed, to these utilitarian applications is the discovery and establishment of abstract scientific truth by men who look to that alone, and whose whole faculties and lives are devoted to it. The men who afterwards make the practical applications of it often attain, indeed, far wider reputations than the real men of science, and become to the popular gaze the representatives of science itself. The higher class are rarely much known to the public during their lives, and are not usually men who would experience any satisfaction if they were nick-named Knights or labelled with C.B., or would feel inclined to accept any other crumbs that might fall from the table of the politically great and powerful. Nor would they commonly care much for pecuniary rewards, unless as a means to enable them to do their work without drudging for the support of themselves or their families. They are the men, however, who in the end rule the world, and doubtless they are often sustained in their labours by a consciousness of this fact.

It would manifestly conduce to the public good and the national honour if such men, when they do arise amongst us, should be sought out, recognized as public benefactors, and allowed means to do that work which their faculties, and theirs only, enable them to perform.

In the meanwhile, the public may insist that all latitude and facilities be given in the public scientific institutions for the carrying on of scientific research, however abstract and remote from practice it may appear to the unscientific intelligence. At present the various authorities under whom scientific public servants have to act too often take as their model the conscientious and cautious parent, who required his boy to know how to swim before he let him go into the water. It is want of knowledge of the real nature and object of scientific museums that causes the House of Commons and the Government to test their value by the number of people who visit them, and the worth of scientific lectures by the number of students who attend them. In each case numbers may be a hindrance to their proper use, and actually tend to prevent even that utilitarian application of them which is so much talked about and so little understood.

The test of the number of visitors must indeed be applied to such a museum as that of South Kensington, where the *ad captandum* principle is avowed, since it shows whether or no the avowed principle has been successful. But from a scientific museum all appeals to the mere taste or the sentiments should be carefully excluded, and the abstract intelligence alone addressed. The one museum admits an object because it is pretty, or, at all events, because it is curious; all mere prettiness and all mere curiosities should be, as far as possible, kept out of the other. The South Kensington Museum exhibits artificial products, "the works of men's hands," the most attractive of them being objects of mere ornamentation. The scientific collections of the British Museum contain the works of Nature, a term I use as a reverential periphrasis for a Higher Name. When scientifically arranged, they exhibit to the trained intelligence that other revelation of which men of science are the Ministers and Interpreters.

To most men Natural History appears a mere amusement of a leisure hour, and the Naturalist, in the world's eye, is below the Artist. It is an old adage that if you give a dog a bad name you might as well hang him, for he will soon be fit for it, and so it comes to pass that Naturalists are too often ready to accept the position the world assigns to them, and give cause for its continuance. It will not long be so, certainly not always.

The Museums that sprang from the Geological Survey attempted

to unite the two principles, and while they were based on scientifically arranged collections of the works of Nature, so far as they were geological and could be obtained within the United Kingdom, they were to contain alongside of these a selection of their utilitarian applications. In a scientific museum, or in a scientific part of a museum, what is to be exhibited is not so much the objects themselves, but their meaning, as displayed by their arrangement. Moreover, as their meanings are manifold, it is necessary to have different museums, in which different arrangements can be adopted in order to display them.

But out of ten thousand visitors to a Geological and Natural History Museum, there is not, perhaps, more than one who sees anything at all of this meaning, and that one is the only person who makes any such use of the museum as it was intended to answer. To apply the test of numbers of visitors to such a museum is about as reasonable as it would be to estimate the value of a library by the number of persons who passed through the rooms and admired the bindings of the books.

As to the lecture system attached to our institutions, large numbers of students were not contemplated, neither, if they came, is there a demand for their services in the world. The value of the few, however, whom we hope to train will certainly be felt in this and the succeeding generations to have amply repaid the cost of that part of our institutions, though it can never appear in "a return," or be put into "a report."

The sole question for the statesman to ask is, as it appears to me, "Is the instruction given sound and real? Is it adapted to answer "a worthy and legitimate end?" If the answer be in the affirmative, he may, I think, safely and wisely leave it to time to attain that end.

I should in such a case appeal to the "wisdom of our ancestors," and ask whether they were actuated by the narrow, short-sighted utilitarian spirit which the present generation boasts of, when they founded our Public Schools and the Colleges in our Universities, and all the grand educational establishments on which so much of our national greatness is based?

In my own college, St. John's, Cambridge, a sum of more than £6,000 is every year shared, from one source or another, among

the *Under-Graduate* students, in addition to the revenues of the Fellows and Master of the College. The other sixteen colleges are similarly provided for according to their size. Oxford has still larger resources, the University of Dublin is richly endowed, and when we add Eton, Westminster, Harrow, Rugby, Shrewsbury, and all the other wealthy educational establishments, we shall begin to have some idea of the vast means given by our forefathers for the advancement and dissemination of the learning and science of their day, and the niggardliness of the present generation in comparison.

"But," some person may say, "these establishments were not "paid for out of the taxation of the country." What does that matter? They were established by so much of the national wealth being set aside for the purpose. If private persons do not now come forward with their contributions, and if our sovereigns and princes have been deprived of the means of doing so and their resources absorbed into the public purse, is it not the duty of the guardians of that purse to take care that the national greatness suffer no diminution at their hands? They may jealously guard against all wasteful expenditure, but they should not imitate the miserly farmer who impoverishes his land because he shrinks from the expense of draining and manuring it.

C.

So little seems to be known of the origin and nature of our institutions, even by the authorities under whom they have subsequently been placed, that in the Appendix to the Tenth Report of the Department of Science and Art (for 1863) in a special Report made by my Lord Granville, Sir C. Trevelyan, and the Right Hon R. Lowe, the Geological Survey, the School of Mines, and the Mining Record Office, are said to have *been gradually connected together as one institution.*

Now, as they all originated simultaneously in one man's mind, and have been developed together as one system, with a tendency, perhaps, towards separation, but have never yet been separated, the phrase, *gradually connected together as one institution*, always struck me as a very curious version of the truth.

But there are what I think more serious errors in that Report than mere careless expressions; one is the very common mistake, that there is an inferior kind of science good enough for practical purposes; and the other that our institutions can be made self-supporting.

The report speaks of "touching on chemistry, general mechanics, "physics, and natural history," only so far as is required for "min-"ing purposes." Such a half-and-half scheme would be exactly the one adapted for the production of half educated quacks, with just a sufficient smattering of knowledge to lead themselves and their employers into all sorts of expensive blunders, which it is the very object of our institutions to put an end to.

Even in chemistry, if I am rightly informed, it is no longer possible to make the distinction between Organic and Inorganic Chemistry, and anyone who wishes to know the true nature of minerals will have to make himself master of Organic Chemistry, and the principles and nomenclature derived from it. It may be from the researches of Organic Chemistry that we may at length be enabled to understand the phenomena even of Mineral Veins.

As to the "self-supporting dodge," for I can call it by no more respectful name, when the Government and Parliament are prepared to pass an Act providing that no one shall practise as a Mining Captain, or Engineer, or Manager, Overlooker, Overseer, or Ground Bailiff, of any mine of any description, without first passing through a recognised School of Mines, and getting its certificate of competency, they may begin to think of making such schools self-supporting.

How many Schools of Medicine and Surgery would have been self-supporting (supposing that any exist which really are so) if the Act of Parliament requiring a student to gain their certificate of attendance and pass their examination before he can practise, had never been passed.

The "School of Mines" in Jermyn-street, and the "School of "Science applied to Mining and the Arts" in Dublin, are really only missionary efforts to try and induce our miners to gain a little more scientific knowledge, and thus enable them, among other things, to impart to us geologists a little more of the knowledge, which is only to be gained in mining, in terms which shall be mutually intelligible. When this interchange of knowledge and experience

really takes place, we shall begin to create some of that farther knowledge also, of which we are both at present destitute, and the only way to acquire that, is either to turn some geologists into miners, or induce some miners to become geologists.

Just at present there is this difference between us, that geologists know and avow their own ignorance, while miners are too often quite unaware of theirs. This was the reason of the failure of the enlightened plans of the late Sir C. Lemon, who offered to provide £10,000 out of his own pocket, if the mining interest of Cornwall and Devon would give an equal sum for the formation of a mining school there. Had the plan been adopted 30 years ago, the mining districts of the West of England, might perhaps, have been spared the failure of their resources and general distress which is said to be now spreading over them.

D.

The vote for the Irish branch of the Survey included, however, at that time one-third of the salaries of the Director-General, the Palæontologist (the late Edward Forbes), and the Mining Geologist (Mr. Warrington Smyth), in consideration of their devoting one-third of their time to Ireland. About ten years ago the office of Mining Geologist was abolished and that of Palæontologist modified.

The following is the estimate for the expenses of the Irish Survey for the year ending March 31st, 1867.

1 Local Director	-	-	£600 0 0
2 Senior Geologists, at £350 each	-	-	700 0 0
1 „ „ „ 305 „	-	-	305 0 0
1 „ „ „ 290 „	-	-	290 0 0
1 „ „ „ 275 „	-	-	275 0 0
1 Assistant „ „ 10s. per diem		-	182 10 0
1 „ „ „ 7s. „	-	-	127 15 0
1 Fossil Collector „ 6s. „	-	-	109 10 0
1 „ „ 5s. 6d. & 6s. „		-	102 12 6
1 Porter and Messenger, at 3s. per diem		-	54 15 0
Travelling expenses	- - -	-	550 0 0
Incidentals „	- - - -	-	230 0 0
			£3527 2 6

A candidate for employment on the Survey on receiving a nomination, has to pass the Civil Service examination, when his pay commences, as Assistant Geologist, at 7s. per diem, increasing 1s. per diem annually, up to 12s. per diem. He then has to wait for a vacancy among the Senior Geologists, whose pay increases by £15 per annum, to a maximum of £350, a salary not so large as it seems, when it is recollected that each officer has to move himself and his family, once, at least, every year into a new locality.

E.

FORM OF THE MAP REGISTERS MENTIONED AT PAGE 11.

County.	Sheet.	Quarter.	Delivered to.	Date.	Received from.	Date.	Remarks.

FORM OF THE SPECIMEN REGISTERS MENTIONED AT PAGE 13.

Number.	Locality.	Formation.	Name.	Destination.	
				Temporary.	Final.

F.

I have always kept in view the possibility of making a wide use hereafter of these Data Maps. When they are completed we should be able to give to any one requiring it a Mineral and Geological Report upon any piece of ground in Ireland, with a copy of our observations marked on the six-inch map, a section across the ground

showing its internal structure, and all the information respecting its mineral capabilities, for mining, quarrying, or other purposes, which it was possible for anyone to obtain.

The cost of such a Report to the persons requiring it, need not exceed the expense of the purchase of the maps, and the time of a copying clerk, and, perhaps, the travelling expenses of one of the Geologists of the Survey, who might be required to make a revision of the ground.

These Geological Reports would have the great advantage of being made by persons who had examined the whole of the neighbourhood, and who had no pecuniary interest in the result. As moreover they would show distinctly the data, or facts, on which they were founded, they would contain within themseives the means of their verification, or correction, by any independent observers.

In mining districts, such as those of England, Wales, and Scotland, the demand for such Reports, when the six-inch map is extended over those countries, would ultimately be both large and constant.

It appears to me, indeed, that in addition to the Head Office in London, it will ultimately be found necessary to establish Local Geological Offices for each of the districts of the present Mining Inspectors, the Resident Geologist of the district working in combination with the Inspector in the collection and registration of all geological information, which may have either a scientific or practical value, and holding himself ready either to receive or impart geological information, from or to, all persons who may be interested in it.

The mistrust which at the first establishment of the Survey was occasionally exhibited by Miners and Coal-owners, apparently from the fear that it might lead to Government interference with their operations, has now entirely disappeared. When the direct practical utility and entire harmlessness of our inquiry come to be understood, indeed, any feeling of distrust is always replaced by cordial assistance and support.

G.

Some little misapprehension of the nature of our work may arise from the use of the term Survey as applied to it. Doubtless, we do mark down on the maps things seen on the surface, and so far we may be said to survey them. Instead of our work being finished, however, when this is done, it is in reality only commenced. These observations are only collecting the *data* and arranging them in their proper relative positions, so that we may see their connection and reason upon them in a strictly logical way.

Our work is in reality more of an *investigation* than a *survey*. When at work in the South Staffordshire coal field, I have often had to spend many days in hunting up evidence respecting some small district which had been worked out perhaps years before. My "witnesses" were, perhaps, ignorant colliers, who often used even their own mining terms in vague and sometimes contradictory senses, and in examining whom I had to be careful never to put a leading question or give the slightest hint which might guide them in any direction, but patiently to listen to one long rambling story after another, and endeavour to pick out the few grains of real information which might at length enable me to make out the truth. I have even sometimes had to spend some days in search of some old fellow who had left the district, but who was said to be able to "tell me all "about it," so that I have often felt more like a lawyer in search of evidence for some great trial than a geologist.

The contradictory use of terms is sometimes most perplexing. Even such a word as "fault" which we geologists have borrowed from coal miners to denote a fracture and displacement of the strata, is used by some in an entirely different sense. I recollect hearing one old and experienced coal and iron master, when examined on an arbitration case declare, that what he understood by a "fault" "was anything which injured or deteriorated the coal."

A "ground bailiff" or colliery manager once assured me that there must be a fault between two adjacent collieries, because a parting between two beds of coal which was two inches thick in one of them was more than two feet at another. Another, after giving me a very accurate description of a "fault" of more than a hundred yards downthrow, finished by assuring me that after all it was only "a slip" and not a fault, for the coal was just the same on both sides of it.

It may easily be understood that men who understand so little of the real nature of the things they were working in, were constantly wasting money in bad mining, in law expenses, and in many other directions. Moreover the experienced gained at great cost by one generation is often utterly lost by the next for want of registration of the facts, and the same costly experiments made again even in the same districts.

H.

When an examination of the whole country shall have been completed, and all the best fossil localities are known, it will be possible to give another and most useful direction to our collecting machinery. Nothing is more wanted than the dissemination through all our schools and local scientific institutions of small picked cabinets of typical specimens of the most common minerals, rocks and fossils. I have often had applications for such specimens, and at one time tried to supply them "on the sly," to use a slang phrase, that is, without formally consulting the Director-General, or asking the sanction of the authorities, or putting myself into fetters of "red tape." I found, however, that I might shortly be hampered in the Survey if I allowed it to grow to a system, and was obliged to discourage the applications.

I believe such cabinets of typical specimens are supplied to schools in France by the French Government, and would beg leave to recommend such a utilisation of the Geological Survey of the United Kingdom to the attention of the Department of Science and Art.

I.

Sections.—I have often been asked how it is that we can tell what lies below the surface, to a depth, sometimes of many hundred feet, without actual excavation. The method is, in fact, simple enough. By continual search, we find at length a place where there is a good exposure of a number of inclined beds rising up to the surface in one direction successively, one from under another. It is

obvious that the bed which last rises up is the lowest bed. Taken in the other direction they *dip* or sink into the earth successively, one under the other; and if we measure the thickness of each bed, we shall get the total amount of cover which rests at one end of the section on the bed which rises to the surface at the other end of it.

As our business is to mark on the map all these "outcrops" as they are called, of different beds and series of beds, it is clear that if there are different exposures of the same series rising up to the surface in different places, some miles apart, their exact average thickness can be ultimately ascertained. We shall then know at any place where we discover the topmost of those beds, for instance, that all the rest lie below it, and how deep it would be to the bottom bed; and the same reasoning would apply to any other identifiable bed of the series.

There are in practice many difficulties in the way of this inquiry which require long training and the exercise of skill and judgment to overcome, since great changes sometimes occur in the nature and thickness of the beds, and their outcrops are often so much concealed as to be only visible at wide intervals, but the method itself is obvious and easy.

J.

Perhaps I may usefully say a few words here as to the only kind of men by whom our work can be properly carried on. It is obvious that the physical toil and intellectual labour required by the Survey can only be undertaken by men whose bodily and mental abilities are above the average. No amount of either, or both, of those qualities, however, will fit a man for our work unless he have that natural instinct for it which will induce him, like Professor Ramsay, and myself, and many other officers of the Survey, knowingly to abandon all hope of wealth, all love of ease, and all ambition of advancement in life, in order to devote his whole energies, thoughts and aspirations to the pursuit of Geology.

A man must be born a geologist, very much as a man is born an artist or a musician. One such man in a few weeks shows an instinctive insight into the nature of our work, and an aptitude for carrying it on, and accordingly an enthusiastic love for it, so that

it would require some pressure to prevent his going on with it; while another man, perhaps even superior to the first in general ability, only acquires the necessary skill and accuracy after years of labour, even indeed if he ever acquire it at all.

For confirmation of the above statements I might appeal to my colleague, Professor Ramsay, as we have both had occasion to remark its truth, and it has been the subject of conversation between us. Any working geologist indeed will I believe tell the same story. It is, in fact, only what occurs in all the natural sciences. Had the Astronomers Royal, or had Professors Owen, Huxley, and Tyndal, and the many other distinguished Professors of Science, gone to the Bar, or the Church, or the practice of Physic, would not the same ability, labour and perseverance which have raised them to a barren eminence in their several pursuits, have elevated them to honour and affluence long before this? The overmastering bent of their inclinations alone determined them to science as the pursuit of their lives, nor do I suppose that they ever regretted it; but without that *overmastering bent of inclination* they would never have submitted to the toils and privations they have had to encounter.

It is this same overmastering bent of inclination which has acted on us, (however inferior we may be to the men I have named in power of intellect or eminence in science), and without that bent I may say certainly for myself that I should long ago have abandoned so labourious and thankless a position as that of an officer on Her Majesty's Geological Survey.

Then, too, as years creep on, one finds oneself chained to the oar by habit, by the impossibility of taking up any other mode of life, and now, at last, I am happy to say, by the prospect of a retiring allowance after a few more years of servitude.

K.

The practical results of the Survey can never be absolutely ascertained, since it is impossible to find out how many persons may have seen and used our publications and been guided by them. This number must necessarily increase every year, as more people become aware of their existence, and still more as the knowledge necessary to make the right use of them extends from year to year. The Survey is in reality designed more for the use of the succeeding generations than for the present, for its publications work their way very slowly even among those who might be supposed to be most interested in them.

The Survey of the whole Kingdom must have been published for some years before it can be expected to have produced its proper effect on the education of the people, and a generation have sprung up capable of appreciating and using its results.

A knowledge of what lies below the surface of the ground in any locality is so obviously a useful knowledge that no words need be expended on the enforcement of its truth.

But surely a still higher species of knowledge is that which is not only aware of what exists, but knows something also of how it came to be. The results of the Geological Survey must contribute largely to both kinds of knowledge.

There are two problems in scientific geology which the Irish branch of the Survey may hope to throw special light upon.

One is that of the true history and classification of the lower part of the Carboniferous formation, since we have in one connected area somewhat of the Scotch type, that of the north of England and that of Derbyshire, and the gradual change into that which has been misunderstood in England and obscured under the name of the Devonian formation.

Another scientific point on which we may hope to throw light is that of the origin of Granite.

Ireland has more granite shown, of more various composition and different ages and more various attendant circumstances than any other similar area I am acquainted with, and if the Irish branch of Her Majesty's Geological Survey of the United Kingdom contribute their share to place the solution of the long-vexed granite problem

on a firm basis they will, in my opinion, have amply repaid the nation the cost of their labours, whatever that may have been.

Those who look for a mere money value in return for the tenth part of a penny, which each person in the United Kingdom contributes annually to the cost of the Geological Survey, or a half-penny among every family of five, may rest comforted with the reflection that it will surely be returned, if not to them, to one of their children or grandchildren, or some other member of their family.